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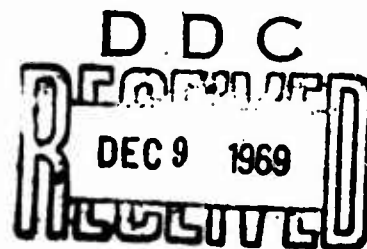
# A 3800 Computer Subroutine Package to Produce Line Printer Plots

DIANNA L. DENTON

*Research Computation Center  
Mathematics and Information Sciences Division*

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RESEARCH & DEVELOPMENT  
CLEARINGHOUSE  
NATIONAL RESEARCH & DEVELOPMENT  
INSTITUTE FOR THE STUDY OF  
TECHNOLOGY



NAVAL RESEARCH LABORATORY  
Washington, D.C.

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#### ABSTRACT

A computer subroutine package written at the University of Wisconsin to produce line printer plots has been modified to run on NRL's CDC 3800 Computer. Line printer plots are valuable for scientists who want a fast and economical method of producing plots but who do not require a high resolution capability.

#### PROBLEM STATUS

A final report on one phase of the problem; work is continuing on other phases.

#### AUTHORIZATION

NRL General and Administrative Function 78-1601

#### ACKNOWLEDGMENTS

The Research Computation Center of the Naval Research Laboratory is indebted to the Computing Center of the University of Wisconsin for supplying the original line printer plot subroutine package and its documentation. The author of this report takes credit only for making modifications, compatibility changes, and documentation changes.

The author is indebted to Doris E. Gossett, Gay H. Rogers, and Douglas P. Shannon of the Research Computation Center for their assistance in preparing this publication.

## A 3800 Computer Subroutine Package to Produce Line Printer Plots

### INTRODUCTION

A computer subroutine package written to produce line printer plots for the Control Data Corporation 3600 Computer by personnel of the Computing Center of the University of Wisconsin, Madison, Wisconsin has been modified for NRL's CDC 3800 Drum SCOPE Computer System. The following subroutine description contains many excerpts from the original documentation received from the University of Wisconsin (Section 3.15, Reference (1)).

The line printer plot subroutine, GRAPHE2, is intended to be valuable for scientists who want a fast and economical method of producing plots of their data but who do not require the high resolution (100 points per inch) of the CALCOMP plotter (Section 3.15, Reference (2)).

Throughout this report, a "plot" will mean one set of axes (abscissa and ordinate) and all the curves to be plotted on this set of axes (e.g. - five curves plotted on one set of axes would be one plot). A "curve" will mean that which is generated from one set of data points by one call to GRAPHE2.

The remainder of this report describes the use of the line printer plot subroutine, GRAPHE2.

## SUBROUTINE DESCRIPTION

### 1.0 IDENTIFICATION

#### 1.1 Title

Line Printer Plot

#### 1.2 Identification Name

J5-NRL-PRPL~~OT~~

#### 1.3 Classification Code

J5 - Output, Plotting

#### 1.4 RCC Identification Number

J5002R00

#### 1.5 Entry Points

GRAPH2  
GRAPH2X  
GRAPH2Y  
GRAPH2XY  
PICTURE

#### 1.6 Programming Language

Language: 3600 FORTRAN and COMPASS 5.3

Routine Type: Subroutine

Operating System: DRUM SCOPE 2.0

#### 1.7 Computer and Configuration

CDC 3800

#### 1.8 Contributor or Programmer

Dianna L. Denton, Code 7817DD, Research Computation Center,  
Mathematics and Information Sciences Division

#### 1.9 Contributing Organization

NRL - Naval Research Laboratory - Washington, D. C., 20390

### 1.10 Program Availability

1.10.1 Submittal: Program write-up, Fortran and Compass source deck, source listing

1.10.2 On File: RCC Program Library

### 1.11 Verification

See Section 7.0, Test Method and Results

### 1.12 Date

10 June 1969

## 2.0 PURPOSE

### 2.1 Description of the Routine

GRAPHE2 produces a plot(s) on the line printer from user specified data (two data arrays). In addition to producing the plot, GRAPHE2 performs the following functions:

- (a) Prints a special symbol for all points on a curve (optional), or uses a standard symbol.
- (b) Prints plot title (optional).
- (c) Prints abscissa and ordinate axes with titles (titles are optional).
- (d) Prints numeric labeling of the axes to indicate magnitudes.
- (e) Allows overlay curves (multiple curves) on one set of axes.
- (f) Determines shifting and scaling so that the data will fit the user specified plot dimensions, or allows the user to specify the shifting and scaling factors.
- (g) Provides for multiple copies of a given plot (entry point PICTURE).
- (h) Allows plots to vary in size between the limits of 5 x 5 inches to 25 x 10 inches, where the abscissa length is specified first.

## 2.2 Problem Background

GRAPE2 was acquired to meet the need of those scientists who want a less expensive and faster method for plotting but who do not require a high resolution capability.

## 3.0 USAGE

The physical appearance of the axes, the axes labels, the axes titles, and the plot title is described in Section 3.8, Output.

Described below (Parts A, B, C, and D) are the four basic calling sequences (Standard, Expanded, Standard Overlay, and Expanded Overlay) for GRAPE2, which assume that the two data arrays (abscissa and ordinate values) to be plotted are TYPE REAL. Part E below gives the entry points to be used when one or both of the data arrays are TYPE INTEGER. Part F below describes the PICTURE subroutine calling sequence.

### A. Standard GRAPE2 Calling Sequence (GRAPE2 Computes Scaling and Shifting).

```
CALL GRAPE2 (X, Y, N, ISIZE, ISCALE, ITITLE, IXTITLE,  
            IYTITLE, ISYMBOL)
```

The above call is used when the

- (1) scaling and shifting factors are to be computed by GRAPE2, and
- (2) the curve is not to be overlaid on the preceding set of axes.

The above call will cause

- (1) the preceding plot (if any) to be printed (unless PICTURE has been called since the previous call to GRAPE2), and
- (2) the new axes, titles, and curve to be generated, but not printed.

### B. Expanded GRAPE2 Calling Sequence (User Supplied Scaling and Shifting Factors).

```
CALL GRAPE2 (X, Y, N, ISIZE, ISCALE, XSHIFT, XSCALE,  
            YSHIFT, YSCALE, ITITLE, IXTITLE, IYTITLE,  
            ISYMBOL)
```

The above call is used when

- (1) the user specifies the scaling and shifting factors, and
- (2) the curve is not to be overlaid on a previous set of axes.

ISCALE must be equal to 4HEXTN (See Section 3.2, ISCALE).

The above call will cause:

- (1) The preceding plot (if any) to be printed (unless PICTURE has been called since the previous call to GRAPE2), and
- (2) the current axes, titles, and curve to be generated, but not printed.

C. Standard Overlay Calling Sequence:

CALL GRAPE2 (X, Y, N, 7H~~O~~VERLAY, ISCALE, ISYMBOL)

The above call is used when the

- (1) scaling and shifting factors are to be computed by GRAPE2, and
- (2) the curve is to be overlaid on the preceding set of axes.

The first curve and the axes of the plot must have been generated using the Standard or Expanded GRAPE2 calling sequence.

The above call causes the current curve to be generated, but not plotted.

All curves of an overlay plot, except the first, must be generated using an Overlay Calling Sequence. Any number of overlay curves may be generated for a particular plot. However, the number of different symbols which may be used to distinguish between the curves is restricted to ten (See Section 3.2, ISYMBOL).

D. Expanded Overlay Calling Sequence:

CALL GRAPE2 (X, Y, N, 7H~~O~~VERLAY, ISCALE, XSHIFT, XSCALE, YSHIFT, YSCALE, ISYMBOL)

The above call is used when the

- (1) user specifies the scaling and shifting factors, and

(2) the curve is to be overlaid on a previous set of axes.

ISCALE must be equal to 4HEXTN (See Section 3.2, ISCALE).

The above call will cause the current curve to be generated, but not plotted.

All curves of an overlay plot, except the first, must be generated using an Overlay Calling Sequence. Any number of overlay curves may be generated for a particular plot. However, the number of different symbols which may be used to distinguish between the curves is restricted to ten (See Section 3.2, ISYMBOL).

#### E. Calling Sequence for Integer Data Array(s):

If one or both of the data arrays are TYPE INTEGER, different entry points of GRAPE2 must be used. The entry point to be used is chosen according to the following table:

<u>Abscissa Array(X)</u>	<u>Ordinate Array(Y)</u>	<u>Entry Point</u>
TYPE REAL	TYPE REAL	GRAPE2
TYPE INTEGER	TYPE REAL	GRAPE2X
TYPE REAL	TYPE INTEGER	GRAPE2Y
TYPE INTEGER	TYPE INTEGER	GRAPE2XY

The parameter lists are the same as described in the calling sequences to GRAPE2. For example, if the abscissa values of the data to be plotted are in the TYPE REAL array X, and the ordinate values are in the TYPE INTEGER array IY, then the Standard Calling Sequence (See A above) is:

CALL GRAPE2Y(X, IY, N, ISIZE, ISCALE, ITITLE, IXTITLE,  
ITITLE, ISYMBOL).

#### F. PICTURE Calling Sequence:

CALL PICTURE

The above call is necessary to

- (1) print the last plot produced in a sequence of one or more calls to GRAPE2, or
- (2) print multiple copies of a plot produced by the previous GRAPE2 call (n calls to PICTURE will produce n copies of the last plot generated by GRAPE2).

For example,

```
CALL GRAPE2 (appropriate parameters)
```

```
CALL PICTURE
```

will generate the plot in the call to GRAPE2 and print the plot in the call to PICTURE. If PICTURE were now called n more times, n more copies of the plot would be printed.

A call to GRAPE2 causes the preceding plot (if any) to be printed. This is true except when PICTURE has been called prior to calling GRAPE2.

### 3.2 Arguments, Parameters, and/or Initial Conditions

#### Initial Conditions:

Before calling GRAPE2 (or GRAPE2X, GRAPE2Y, or GRAPE2XY), 2 one-dimensional arrays, containing the data to be plotted, must be stored in the computer (one array containing the abscissa values, the other the ordinate values). Each of these arrays can be either TYPE REAL or TYPE INTEGER (See the X and Y parameters below). In Section 3.1 Parts A, B, C, and D, calling sequences are described for the TYPE REAL case only. In Section 3.1, Part E, the use of GRAPE2 when one or both of the coordinate arrays are TYPE INTEGER, is described.

#### Parameters:

- X - TYPE REAL array containing the abscissa values to be plotted. To use a TYPE INTEGER array, see Section 3.1.
- Y - TYPE REAL array containing the ordinate values to be plotted. To use a TYPE INTEGER array, see Section 3.1.
- N - integer number which specifies both
  - (1) the number of points to be plotted, and
  - (2) the plotting mode.

If N is positive, the effect of a continuous line is produced by use of linear interpolation to fill in values between successive data points. (Since this is analogous to pen-down plotting

mode on a plotter, it will hereafter be referred to as "pen-down" mode). If N is negative only those points contained in the arrays are plotted. (This will be referred to as "pen-up" mode). The first  $|N|$  points of the X and Y arrays are plotted;  $|N|$  must be  $\leq$  the size of the X and Y arrays.

ISIZE - a Hollerith designator which specifies the dimension (in inches) of the plot.

ISIZE = 5ELARGE for an 8 x 16 inch plot

ISIZE = 5ESMALL for a 6 x 8 inch plot

ISIZE = 5BoxXyy for a user specified plot size where,

xx = X-axis length in inches ( $5 \leq xx \leq 25$ )

yy = Y-axis length in inches ( $5 \leq yy \leq 10$ )

ISCALE - a Hollerith designator which specifies the type of scaling to be used on the data.

(1) Automatic Scaling: ISCALE = 4HAUTY

Automatic scaling causes the program to fit the data points into the plot size as specified by the parameter ISIZE. To locate the origin, the plot is classified into one of three types in each direction. This classification depends upon the signs of the maximum and minimum values of each of the two coordinate arrays.

The position of the origin-point of the plot within the defined plotting rectangle is shown in Figures 1a. and 1b. Combinations of the two sets of figures are permitted.

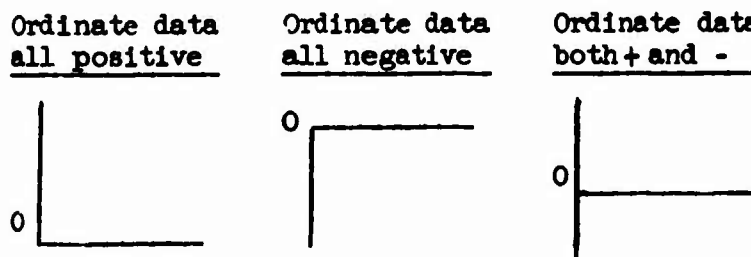


Figure 1a: Position Of The Ordinate Origin As A Function Of The Sign Of The Ordinate Data.

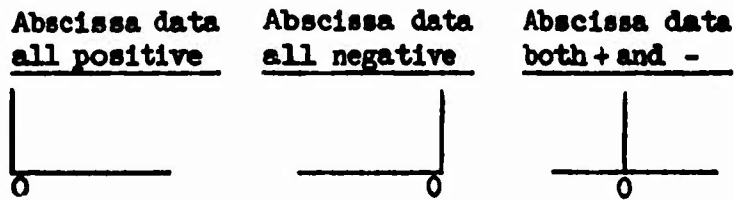


Figure 1b: Position Of The Abscissa Origin  
As a Function Of The Sign Of The  
Abscissa Data.

Scaling of the curve data is by powers of two such that the resultant curve occupies at least one-half of the allowable plotting length for each coordinate axis. For best results, if  $M$  is the maximum of the absolute values of the data for one axis, the length of that axis in inches, as specified by the parameter  $ISIZE$ , should be slightly greater than (or exactly equal to) one of the terms of the sequence . . .  $1/4M$ ,  $1/2M$ ,  $M$ ,  $2M$ ,  $4M$ , . . . .

For example, suppose that the abscissa coordinate values of the points to be plotted range from 31.5 to 46.0, so that  $M = 46.0$ . Then the best choices of abscissa axis length, in inches are: 23 (exactly  $1/2M$ ), 12 (slightly greater than  $1/4M$ , and 6 (slightly greater than  $1/8M$ ).

(2) Biased Scaling:  $ISCALE = 4HBIAS$

Under this option, the minimum value of each coordinate array is subtracted from the corresponding coordinate of each data point before the point is plotted. For each axis, scaling is by powers of two, as above, except that the difference between the maximum and minimum values of the data for that axis (rather than the maximum of the absolute values of the data for that axis) is used to determine the scale factor. For best results, the corresponding axis length as specified by the parameter  $ISIZE$  should be equal to or slightly greater than this difference times a power of two.

(3) Repeated Scaling and Shifting Factors:

ISCALE = 4BSAME

With this option, the scaling and shifting factors used in the previous plot are also to be used in producing the current plot. This option should be used with the Standard Overlay Calling Sequence if each curve is to be shifted and scaled by the same values as the immediately preceding curve. If the shifting and scaling is to be different, see the other ISCALE options. However, it should be remembered that the numeric values written on each axis are based on the scaling and shifting factors used for the first curve plotted on those axes.

(4) Unscaled Data: ISCALE = 4NONE

This option is provided to plot the data with no scaling or shifting. When using this option the user must be sure that his data is properly scaled and centered to fit into the plot size.

(5) User Specified Scaling and Shifting:

ISCALE = 4EXTIN

This option causes the four real parameters, XSHIFT, XSCALE, YSHIFT, and YSCALE, to be used for shifting and scaling the data. This option can only, and must, be used in the Expanded GRAPE2 calling Sequence (See Section 3.1, Part B), and in the Expanded Overlay Calling Sequence (See Section 3.1, Part D).

If  $X_1$  and  $Y_1$  are unscaled abscissa and ordinate values respectively, then the corresponding plotted values in inches, relative to the lower left hand corner of the plot rectangle after rotation (see Section 3.8) will be:

$$\frac{X_1 - XSHIFT}{XSCALE} \quad \text{and} \quad \frac{Y_1 - YSHIFT}{YSCALE}$$

**XSHIFT** - A real value which specifies the amount of shift for the abscissa values. The point on the x-axis at the lower left-hand corner of the plot rectangle after rotation (see Section 3.8) will be annotated by XSHIFT.

**XSCALE** - a real value which specifies the scale factor for the shifted abscissa values. This is the increment used to increase **XSHIFT** to calculate the annotation value and the plotted value for each tick mark after the first tick mark (where a tick mark occurs every inch). Thus, the annotation and the value plotted at the  $n$ th tick mark will be  $XSHIFT + (n-1) XSCALE$ .

**YSHIFT** - a real value which specifies the amount of shift for the ordinate values. The point on the y-axis at the lower left-hand corner of the plot rectangle after rotation (see Section 3.8) will be annotated by **YSHIFT**.

**YSCALE** - a real value which specifies the scale factor for the shifted ordinate values. This is the increment used to increase **YSHIFT** to calculate the annotation value and the plotted value for each tick mark after the first tick mark (where a tick mark occurs every inch). Thus, the annotation and the value plotted at the  $n$ th tick mark will be  $YSHIFT + (n-1) YSCALE$ .

**Example of shifting and scaling:**

If the abscissa values range from 15.0 to 17.0 and the abscissa axis length as specified by the parameter **ISIZE** is 5 inches then setting **XSHIFT** = 15.0 and **XSCALE** = 0.4 would cause the abscissa values to be shifted and scaled into the range 0.0 to 5.0 inches, which is the greatest possible range which will contain the data within the axis length of 5 inches.

**ITITLE** - specifies the plot title in one of the following two ways:

- (1) a list of characters following a Hollerith designator.
- (2) the name of an integer variable or array in which are stored the internal BCD codes of the characters of the desired title, packed eight codes per word, left adjusted if less than eight characters.

Regardless of the way in which the title is specified, it may be at most 48 characters in length. If less than 48 characters are desired, the last two characters must be periods. **GRAPE2** will remove the terminating periods and the desired characters will be centered appropriately before plotting. If no

title is desired, the corresponding parameter may be given the value zero. Or, if none of the subroutine parameters following ITITLE are to be used, the ITITLE parameter and those parameters which follow it may be omitted from the calling sequence.

Four examples of the various ways of specifying titles, and the corresponding output they produce, follow:

- (1) ITITLE = 48H            GRAPH1 SAMPLE, EXPANDING  
                             SINE WAVE

will produce the title

GRAPH1 SAMPLE, EXPANDING SINE WAVE

Since the title, which includes seven blanks following WAVE, is a full 48 characters in length, the last two characters are not periods.

- (2) ITITLE = 7HANGLE..

will produce the title

ANGLE

Since the title is less than 48 characters in length, the last two characters must be periods.

- (3) ITITLE = 0

will produce no title. When the title parameter is zero, no title is produced.

- (4) ITITLE = IL where the variable IL contains 62436074533433338 will produce the title SL (\$) since IL contains the BCD codes for SL (\$) followed by two periods.

IXTITLE - specifies the abscissa axis title in the same form and with the same rules as for ITITLE above, with the following

exception:

The maximum abscissa axis title length depends on the length of the abscissa axis. If the abscissa axis length is greater than or equal to 8 inches the maximum title length is 48 characters, as given under ITITLE. However, if the axis length is less than 8 inches, the maximum number of characters in the abscissa axis title is equal to 6\* (axis length).

ITYTITLE - specifies the ordinate axis title in the same form and with the same rules as for ITITLE above.

ISYMBOL - is an optional parameter (Hollerith) used to specify the character to be used by the printer to represent a given set of data points. For example, if ISYMBOL = 1A, the letter A would be used to plot the curve. If ISYMBOL is not present as the last parameter in the calling sequence, GRAPH2 automatically uses an asterisk (\*) for pen-down plotting and a plus sign (+) for pen-up plotting (See description of parameter N above).

When producing an overlay plot, the number of different characters that may be used to differentiate between the various curves is restricted to ten (e.g. - to produce 11 curves on one plot, only ten different symbols can be used; two curves would have to use the same symbol).

### 3.3 Space Required (Decimal and Octal)

#### 3.3.1 Unique Storage:

4112 octal (2122 decimal) locations excluding the common block and system library routines.

#### 3.3.2 Common Blocks:

COMMON/18273645/

Length: 11031 octal (4633 decimal) locations

### 3.3.3 Temporary Storage:

None

### 3.4 Messages and Instructions to the Operator

None

### 3.5 Error Returns, Messages, and Codes

Each of the following error messages are preceded by the identifier \*GRAPHE2/.

(1) Error Message BAD SIZE/USED ABSCISSA = 25

Cause The length of the X-axis as specified by ISIZE was less than 5 inches or greater than 25 inches.

Action GRAPHE2 will generate the current plot using an abscissa length of 25 inches.

(2) Error Message BAD SIZE/USED ORDINATE = 10

Cause The length of the Y-axis as specified by ISIZE was less than 5 inches or greater than 10 inches.

Action GRAPHE2 will generate the current plot using an ordinate axis length of 10 inches.

(3) Error Message N EQUAL ZERO

Cause The number of data points was specified as zero.

Action Current call to GRAPHE2 will be ignored.

(4) Error Message ALL X ESSENTIALLY ZERO

Cause This generally means that all abscissa data had absolute values of less than  $10^{-200}$ . When Bias Scaling is specified, this message may also mean that the range of the data was less than  $10^{-200}$ .

Action Current call to GRAPE2 will be ignored.

(5) Error Message ALL Y ESSENTIALLY ZERO

Cause This generally means that all ordinate data had absolute values of less than  $10^{-200}$ . When Bias Scaling is specified, this message may also mean that the range of the data was less than  $10^{-200}$ .

Action Current call to GRAPE2 will be ignored.

(6) Error Message OVERLAY ERROR

Cause An attempt has been made to generate an overlay curve prior to generating a set of axes by using either the Standard or Expanded GRAPE2 calling sequence.

Action Current call to GRAPE2 will be ignored.

(7) Error Message MORE THAN 10 UNIQUE SYMBOLS

Cause This message occurs when an overlay call specifies an eleventh unique symbol to be used on one set of axes.

Action The current call to GRAPE2 and all preceding calls pertaining to this set of axes will be ignored.

(8) Error Message THIS PLOT OR OVERLAY NOT DONE

Cause This message follows all error messages of the type which cause the current call to GRAPE2 to be ignored.

3.6 Informative Messages to the User

None

3.7 Input

None

### 3.8 Output

See the sample plots in Section 7.0.

The generated line printer plot will have the following automatic features:

#### (1) Axes

- (a) The axes will be drawn the length specified by the ISIZE parameter.
- (b) Each axis will be numerically labeled at every inch along the axis.
- (c) Each axis is composed of periods (.) and plus signs (+) with the plus signs occurring only at each inch increment along the axis. The periods are written between the plus signs.
- (d) The abscissa axis will be parallel to the paper sprocket holes.
- (e) The ordinate axis will be perpendicular to the sprocket holes.

If the line printer page is rotated counterclockwise 90°, the axes will be in the normal X, Y axis arrangement.

- (f) All numeric labeling of the axes is written with either an F or E Fortran I/O format (depending on the size of the values) giving 3 places to the right of the decimal point.

#### (2) Titles

- (a) The abscissa axis title is written parallel to the abscissa axis.
- (b) The ordinate axis title is written parallel to the ordinate axis.
- (c) The plot title is written parallel to the ordinate axis, above the ordinate axis title.

#### (3) Data Curves

Unless specified otherwise by the ISYMBOL parameter, the plotted curves will have an asterisk (\*) at each

coordinate if the parameter N is positive (pen-down mode), or a plus sign (+) if the parameter N is negative (pen-up mode). The pen mode is defined in Section 3.2, in the N parameter description.

### 3.9 Formats

Not applicable

### 3.10 External Routines and Symbols

GRAPH2A	}	J5002R00	Package Deck
GRAPH2B			
GRAPHZ			
Q8QG2PRT			
SEARCH			

GRAPH2X, GRAPH2Y, GRAPH2XY, and PICTURE are  
entry points in GRAPH2.

LQGF	Q1Q04100	DEC.	STH.	}	system library
MAXIF	Q1Q10100	QNSINGL.	ENC.		
XMAXOF	Q8QEFRO	THEEND	SLP.		
XMINOF	Q8QDI6T	Q2Q07110	IP.		

### 3.11 Timing

See the timing for the sample plots in section 7.0

### 3.12 Accuracy

The resolution of the line printer is 10 points per inch for the ordinate axis and 6 points per inch for the abscissa axis.

### 3.13 Cautions to Users

- (1) If you want the plots to be printed on plain white printer paper, you should write "FINAL FORM" at the top of your Job Request Form. Otherwise, you will get whatever paper is on the line printer at the time of your run. Jobs asking for "FINAL FORM" usually are not run until the night shift.
- (2) If the parameter ISCALE equals 4HAUTP or 4HBIAS, it is required that both the coordinate arrays contain some non-zero data. If all the data in either of the arrays is zero, an error message is printed and no curve (or

plot) is produced.

- (3) Any attempt to plot data outside the selected plot size will result in the data point in question being plotted on the inside edge of the plot perimeter.

### 3.14 Program Deck Structure

7 JOB card  
9

7 FIN card  
9

Main Program deck (contains call to GRAPE2)

Subroutine GRAPE2	} J5-NRL-PRPLOT
Subroutine GRAPE2A	
Subroutine GRAPE2B	
Subroutine GRAPEZ	
Subroutine Q8QG2PRT	
Subroutine SEARCH	
SCOPE card	

7 LOAD card  
9

7 RUN card  
9

Data (if any)

77 (end-of-file card)  
88

### 3.15 References - Literature - Appendices

- (1) GRAPH PLOTTING VIA CALCOMP 570 DIGITAL PLOTTER, The University of Wisconsin Computing Center Users Manual, Revisions A and B, 24 May 1965 and 1 December 1966.
- (2) 3800 CALCOMP PLOTTER SUBROUTINE PACKAGE, PRELIMINARY VERSION, RCC Memorandum 7810-5:ABB:pj, 18 September 1967.

### 4.0 METHOD OR ALGORITHM

See the author

### 5.0 SOURCE LANGUAGE LISTING

Available in the RCC Program Library

## 6.0 COMPARISON

None

## 7.0 TEST METHOD AND RESULTS

Following are the listings of three sample programs which use GRAPH2. The approximate timing for each call is given.

Sample 1: Program ESW below was used as a test program.

```
PROGRAM ESW
DIMENSION X(250),Y(250)
DO 100 I=1,250
  X(I) = I-1
100 Y(I) = SIN(X(I)/14,325)*EXP(X(I)/100,0)
  CALL GRAPH2(X,Y,250,3H5X6,4HAUTO,21HEXPANDING SINE WAVE,,
  1 7HANGLE,,11HMAGNITUDE,,)
  CALL PICTURE
END
```

See Figure 1 for the resulting output.

Timing:

Call to GRAPH2: 0.21 seconds

Call to PICTURE: 0.21 seconds

Sample 2: Program SSCP below illustrates the overlay capabilities of GRAPH2. The output simulates the output in the sample given in the CalComp Plotter Subroutine Package description (Section 3.15, Reference 2).

```
PROGRAM SSCP
DIMENSION FEX(71),FXCUBE(71),FXLINEAR(71),XPLOT(71)
X = 1,0
DO 100 I=1,71
  FEX(I) = EXP(X)/10,0
  FXCUBE(I) = (X**3+7,0)/10,0
  FXLINEAR(I) = (X+20,0+4,0)/10,0
100 X = X+0,05
  XPLOT(I) = 0
DO 200 I=2,71
200 XPLOT(I) = XPLOT(I-1)+0,1
  CALL GRAPH2(XPLOT,FEX,-71,4H7X10,4HAUTO,
  1 31MSIMULATED SAMPLE CALCOMP PLOT,,10HABSCISSA,,10HORDINATE,,)
  CALL GRAPH2(XPLOT,FXCUBE,71,7HOVERLAY,4HSAHE)
  CALL GRAPH2(XPLOT,FXLINEAR,71,7HOVERLAY,4HSAHE,1H,)
  CALL PICTURE
END
```

See Figure 2 for the resulting output.

Timing:

First call to GRAPH2:	0.09 seconds
Second call to GRAPH2:	0.05 seconds
Third call to GRAPH2:	0.04 seconds
Call to PICTURE:	0.36 seconds

Sample 3: Program LPPLT below illustrates overlay calls and the use of the expanded calling sequence.

```

PROGRAM LP PLOT
DIMENSION A(3),B(40),J(3),X(81),Y(81)
DATA (A=2,0,4,0,6,0), (J=1WA,1WB,1WC)
K = 1
X(1) = -2,0
DO 100 I=1,40
  B(I) = SQRTF(X(I)**2*(4,0-X(I)**2))
  X(82-I) = X(I)
100 X(I+1) = X(I)+0.1
  X(41) = 2,0
200 DO 300 I=1,40
  Y(I) = A(K)+B(I)
300 Y(82-I) = A(K)-B(I)
  Y(41) = A(K)
GO TO (400,500) K
400 CALL GRAPH2(X,Y,81,3H6X8, 'HEX7N',3,0,1,0,0,1,0,0,3HX,,,3HY,,,J(K))
GO TO 600
500 CALL GRAPH2(X,Y,81,7H0VERLAY,4HSAME,J(K))
600 K = K+1
GO TO (200,200,700) K=1
700 CALL PICTURE
END

```

See Figure 3 for the resulting output.

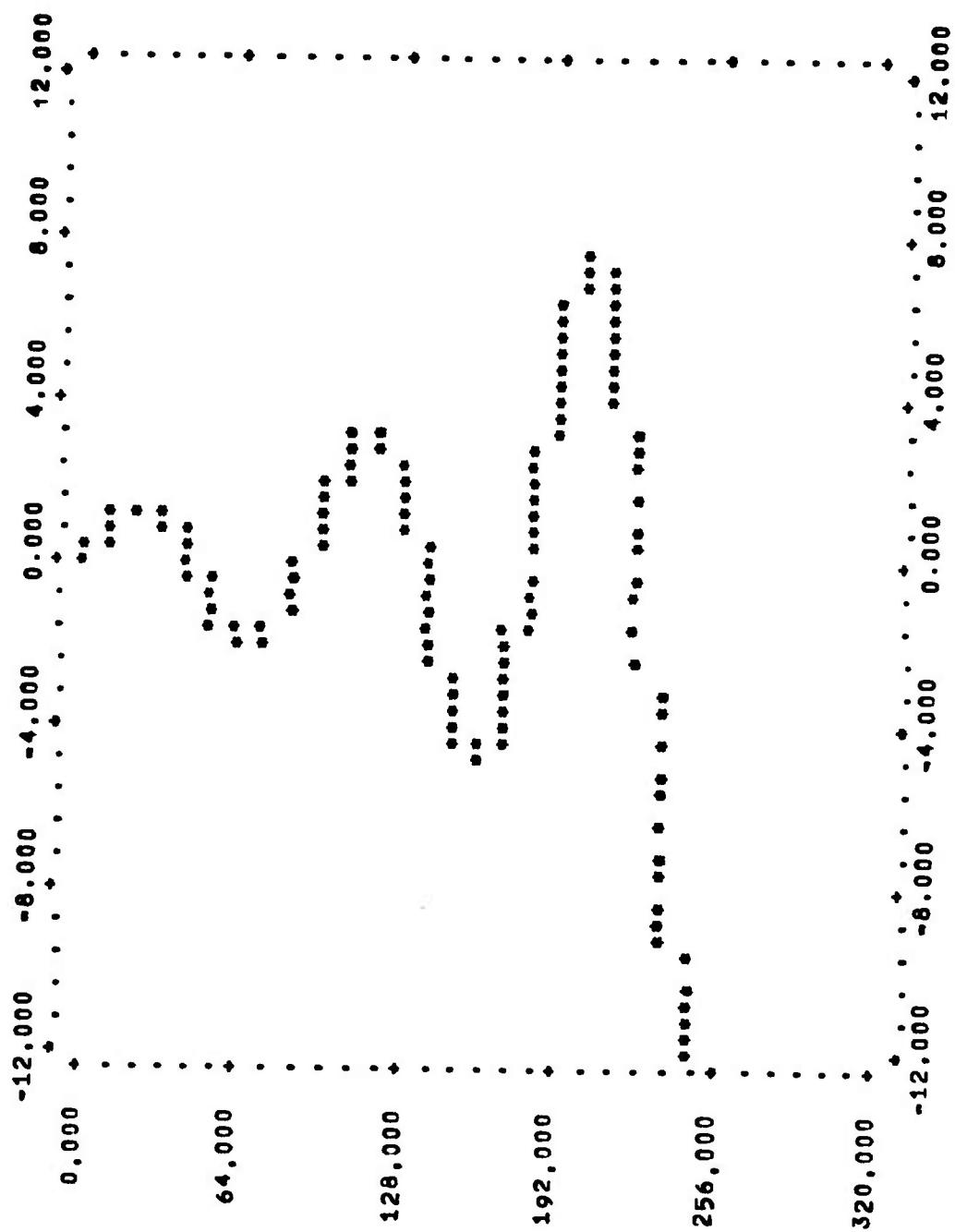
Timing:

First call to GRAPH2:	0.12 seconds
Second call to GRAPH2:	0.07 seconds
Third call to GRAPH2:	0.07 seconds
Call to PICTURE:	0.32 seconds

## 8.0 REMARKS

None

**MAGNETUDE**



### Figure 1

← 20 ←

SIMULATED SAMPLE CALCOMP PLOT

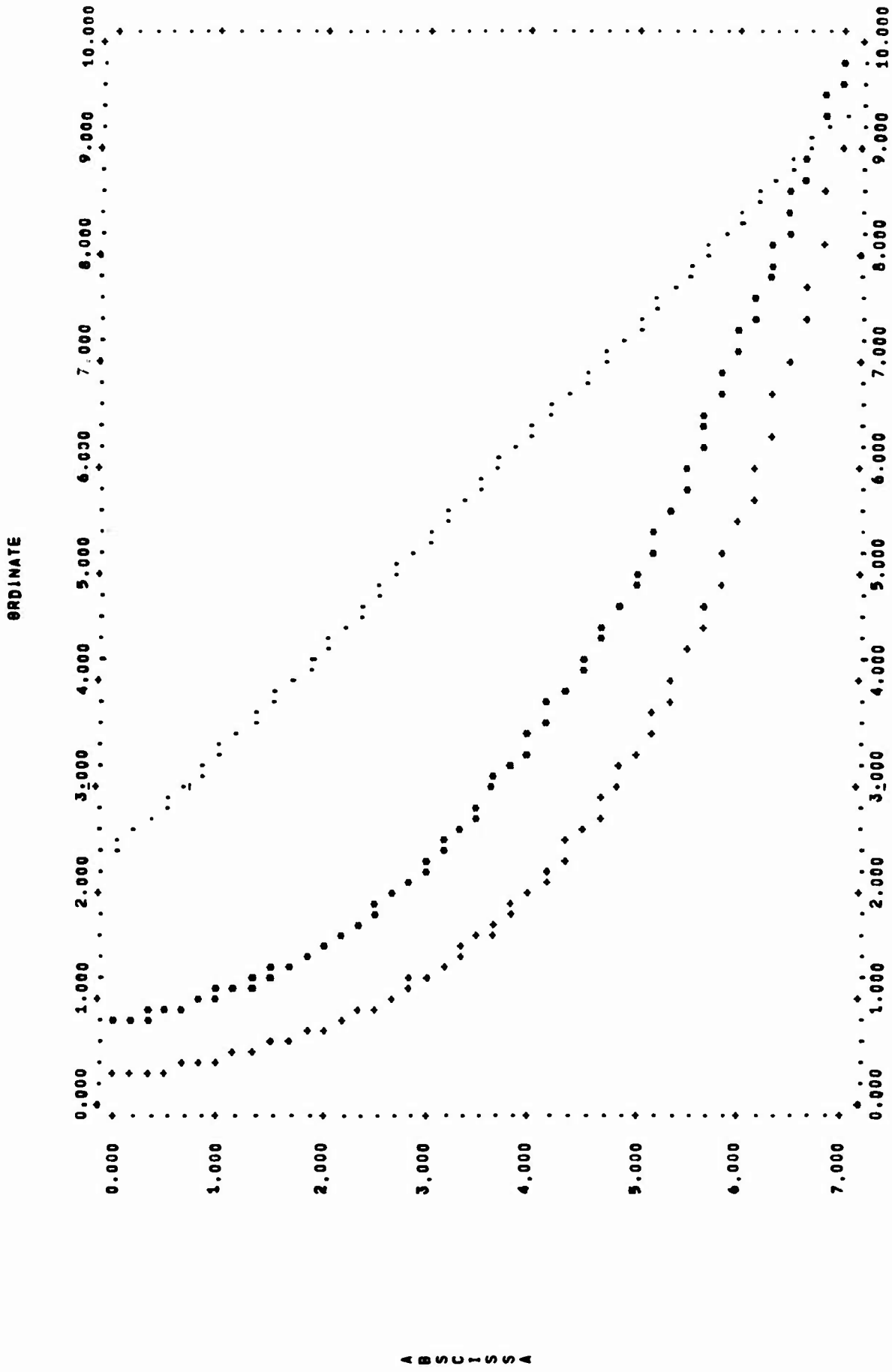


Figure 2

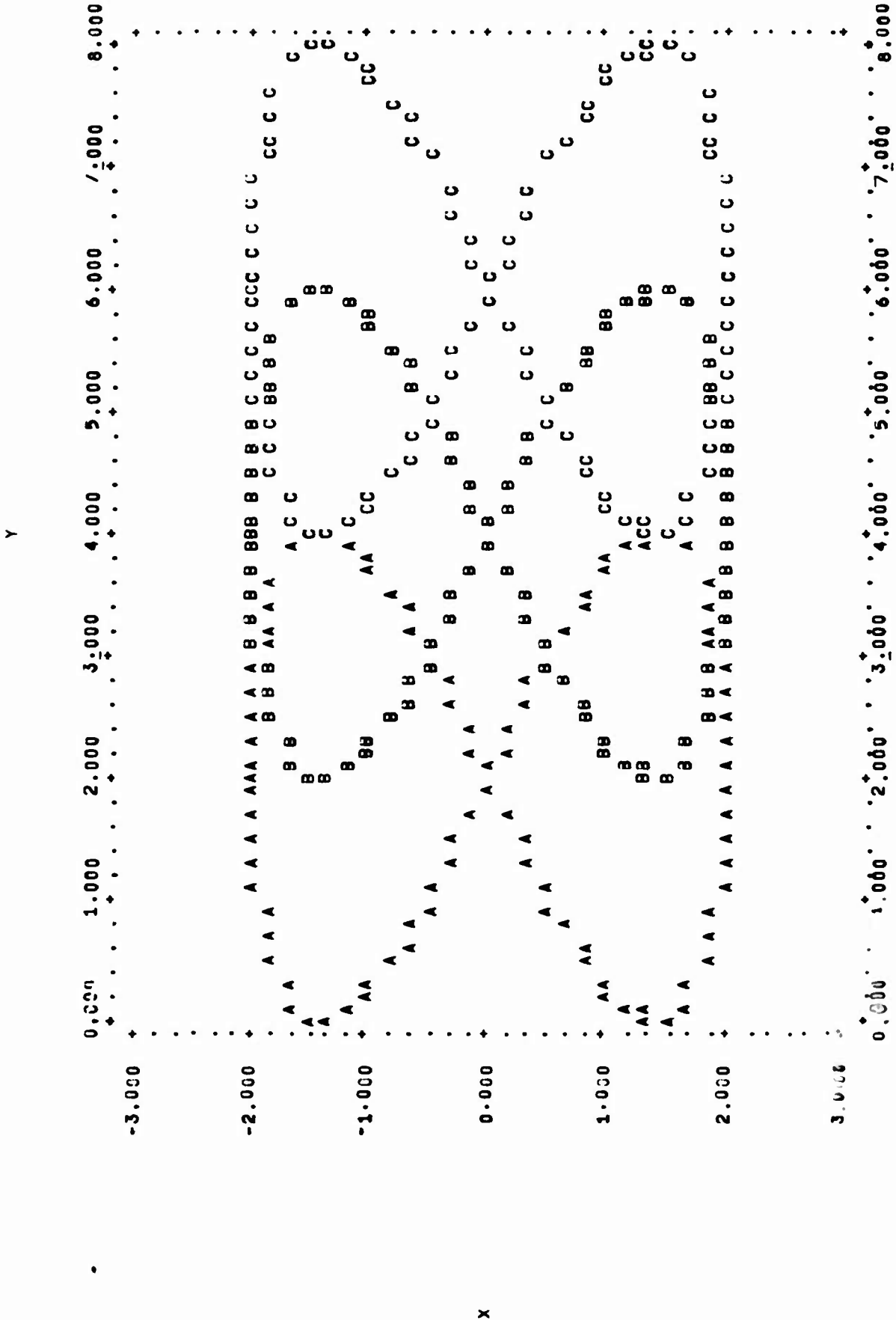


Figure 3

UNCLASSIFIED

Security Classification

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<small>(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)</small>		
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13. ABSTRACT  A computer subroutine package written at the University of Wisconsin to produce line printer plots has been modified to run on NRL's CDC 3800 Computer. Line printer plots are valuable for scientists who want a fast and economical method of producing plots but who do not require a high resolution capability.		

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